Velu Prabhakar Kumaravel

Date of birth: 24/06/1991 | **Nationality:** Indian | (+39) 3923267459 |

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Via Sommarive, 18, 38123, Trento, Italy

WORK EXPERIENCE

01/02/2022 – 31/07/2022 – Lausanne, Switzerland

VISITING PHD STUDENT – SWISS FEDERAL INSTITUTE OF TECHNOLOGY LAUSANNE (EPFL)

During my 6-months Ph.D. internship, I was involved in PEDESITE (Personalized Detection of Epileptic Seizure in the Internet of Things (IoT) Era), funded by the Fonds National Suisse de la Recherche Scientifique. I worked in Machine Learning approaches to enhance the detection of epileptic seizures.

EDUCATION AND TRAINING

01/11/2018 – CURRENT – Trento, Italy

PHD IN COGNITIVE AND BRAIN SCIENCES – Fondazione Bruno Kessler / Center for Mind-Brain Sciences (CIMeC), University of Trento

The goal of my Ph.D. is to bring mobile EEG solutions for investigating neural correlates of cognitive functions in human newborns/infants.

My tasks and responsibilities include

1. Develop an artifacts pre-processing pipeline for newborn/infant high-density EEG (offline processing based on EEGLAB).
2. Developing MATLAB-based software for pre-processing and neural feature extraction using our custom 8-electrode wearable EEG setup.
3. Developing firmware (embedded C) for the online artifacts processing specific to our custom EEG system.

Address Trento, Italy

Bologna, Italy

MASTER OF SCIENCE IN TELECOMMUNICATIONS ENGINEERING – University of Bologna

Address Bologna, Italy |

Thesis Experimental Evaluation of BITalino: A Low-cost Modular Platform for Biosignals Acquisition

Chennai, India

BACHELORS OF ENGINEERING IN ELECTRONICS AND COMMUNICATIONS ENGINEERING – Madras Institute of Technology, Anna University

Address Chennai, India |

Thesis Biomedical Image Segmentation using Combined Watershed and Level Set Method

DIGITAL SKILLS

My Digital Skills

EEG Signal Processing | Biomedical Signal Processing | Python | MATLAB/EEGLAB | Linux | Statistical Analysis | Machine Learning | LaTeX

FUNDED RESEARCH PROJECTS

01/11/2019 – 31/10/2021

Researcher in NeuroSoNew: Portable EEG-based screening of social predispositions in newborns

ERC-2018-PoC - ERC Proof of Concept Grant of EUR 149,945 (ID: 842243)

Earlier studies revealed that newborns with Autism-Spectrum Disorders (ASD) demonstrate different preferences to face processing compared to healthy populations. This project aims at designing a portable EEG for a rapid & reliable investigation of neural correlates of face processing in newborns to assist in an early diagnosis of ASD. My role in this project is to develop advanced signal-processing tools for pre-processing and extracting neural features from newborn data. I also collaborate with researchers from the University of Bologna to port the solutions into the resource-constrained MCU platform.
https://cordis.europa.eu/project/id/842243

HONOURS AND AWARDS

30/09/2022

Think Open @ CIMeC Awards 2022 – Center for Mind/Brain Sciences, University of Trento, Italy

This is awarded to my open-source toolbox (NEAR) that complies with all the FAIR (Findability, Accessibility, Interoperability, and Reusability) principles and at the same time carrying high scientific relevance in the field of developmental cognitive science.
https://twitter.com/cimec_unitrento/status/1575797402061049857

27/01/2022

Third Selected PhD Talk – Center for Mind/Brain Sciences, University of Trento, Italy

My PhD project is chosen as the third best for the CIMeC Doctoral Day 2022.
https://twitter.com/cimec_unitrento/status/1486692452442558472

28/01/2021

CIMeC Doctoral Day - Best Poster Award – Center for Mind/Brain Sciences, University of Trento, Italy

Best poster award for presenting my research work as a part of CIMeC Doctoral Day.
https://github.com/vpKumaravel/dsday2021_poster

2015

UNIBO Azione 1 Grant Award – University of Bologna, Italy

Full tuition fee waiver granted by the University of Bologna to the International Students.

Star Award Winner for Two Consecutive Times (2014) – Larsen & Toubro Infotech

Quarterly-award dedicated to best performers in the Business Unit.

PUBLICATIONS

NEAR: An artifact removal pipeline for human newborn EEG data

SI: Developmental EEG Methods - A Tutorial Approach (Developmental Cognitive Neuroscience)
https://www.sciencedirect.com/science/article/pii/S1878929322000123 – 2022

Electroencephalography (EEG) is arising as a valuable method to investigate neurocognitive functions shortly after birth. However, obtaining high-quality EEG data from human newborn recordings is challenging because compared to adults and older infants, datasets are typically much shorter due to newborns' limited attentional span and much noisier due to non-stereotyped artifacts mainly caused by uncontrollable movements. Here we propose Newborn EEG Artifact Removal (NEAR), a novel pipeline for EEG artifact removal specifically designed for human newborns. NEAR is based on two key steps: 1) A novel bad channel detection tool relying on the Local Outlier Factor (LOF), a robust outlier detection algorithm; 2) A parameter calibration procedure for adapting Artifacts Subspace Reconstruction (ASR), a method primarily developed for artifact removal in mobile adult EEG, to newborn EEG data. NEAR is trained and validated on two different newborn EEG datasets recorded with a frequency-tagging paradigm, an experimental design that tackles the limitation of newborn's attentional span by maximizing the signal-to-noise ratio. Validation shows that NEAR outperforms existing methods for both bad channel detection and overall artifact removal, matching expert performance in obtaining statistically significant EEG responses from noisy datasets. NEAR consists of a set of freely available EEGLABbased custom scripts (https://github.com/vpKumaravel/NEAR).
https://github.com/vpKumaravel/NEAR

Adaptable and Robust EEG Bad Channel Detection Using Local Outlier Factor (LOF)

Sensors, MDPI Journal
https://www.mdpi.com/1424-8220/22/19/7314/htm – 2022

Electroencephalogram (EEG) data are typically affected by artifacts. The detection and removal of bad channels (i.e., with poor signal-to-noise ratio) is a crucial initial step. EEG data acquired from different populations require different cleaning strategies due to the inherent differences in the data quality, the artifacts' nature, and the employed experimental paradigm. To deal with such differences, we propose a robust EEG bad channel detection method based on the Local Outlier Factor (LOF) algorithm. Unlike most existing bad channel detection algorithms that look for the global distribution of channels, LOF identifies bad channels relative to the local cluster of channels, which makes it adaptable to any kind of EEG. To test the performance and versatility of the proposed algorithm, we validated it on EEG acquired from three populations (newborns, infants, and adults) and using two experimental paradigms (event-related and frequency-tagging). We found that LOF can be applied to all kinds of EEG data after calibrating its main hyperparameter: the LOF threshold. We benchmarked the performance of our approach with the existing state-of-the-art (SoA) bad channel detection methods. We found that LOF outperforms all of them by improving the F1 Score, our chosen performance metric, by about 40% for newborns and infants and 87.5% for adults.

Efficient Artifact Removal from Low-Density Wearable EEG using Artifacts Subspace Reconstruction

International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)
https://ieeexplore.ieee.org/document/9629771 – 2021

With the advent of hardware-software co-design, cost-effective portable and wireless EEG systems are made possible for both remote clinical monitoring and BCI (Brain-Computer Interfaces) applications. However, the quality of the collected data from such systems can be largely hampered by the presence of movement artifacts often leading to misclassification of neural features. A recently developed Artifacts Subspace Reconstruction (ASR) is a promising solution to remove non-stationary and non-stereotypical artifacts common in mobile EEG settings with high sensitivity and specificity. Since ASR has only been validated with high-density EEG systems (channels > 32), it was unclear whether it was equally efficient on low-density (channels = 8, or 16) mobile EEG systems. Cheng et al. empirically provided an empirical lower limit on the number of channels as 20 for an efficient artifact cleaning but a systematic validation was still missing. The technical merit of this paper is its first-time validation of ASR on clean and contaminated Steady-State Visually Evoked Potential (SSVEP) data acquired with an ultra-low-power custom EEG system 'BioWolf' with 8 dry electrodes. *Significance*: Results indicate that ASR can be used in low-density EEG acquired with just eight electrodes to remove the non-stereotypical artifacts. Moreover, our chosen SSVEP paradigm is one of the most widely used in BCI applications. Altogether, the results promise a robust portable BCI system especially for recordings in natural context using ASR as a pre-processing technique in the near future.

Hyperparameter selection for reliable EEG denoising using ASR: a benchmarking study

IEEE International Conference on Bioinformatics and Biomedicine (BIBM)
https://ieeexplore.ieee.org/document/9669561 – 2021

Artifacts preprocessing in EEG is remarkably significant to extract reliable neural responses in the downstream analysis. A recently emerging powerful preprocessing tool among the EEG community is Artifacts Subspace Reconstruction (ASR). ASR is an unsupervised machine learning algorithm to identify and correct the transient-like non-stationary noisy samples. ASR is fully automatic, therefore, suitable for online applications. However, the performance of ASR is strongly dependent on the user-defined hyperparameter k. A poor choice of k might lead to severe performance degradation.In this work, we benchmark the performance of ASR against its parameter k. Toward this goal, we used the Temple University Hospital EEG Artifact Corpus (TUAR), which consists of 310 EEG files recorded in clinical settings from epileptic patients. Remarkably, these files are annotated for artifacts by trained personnel with a high inter-rater agreement score ($\kappa > 0.8$). Considering these reliable labels as ground truth, ASR has shown the best performance in artifacts cleaning with k ranging between 20 and 40.

Towards a Domain-specific Neural Network Approach for EEG Bad Channel Detection

IEEE Signal Processing in Medicine and Biology (SPMB)
https://ieeexplore.ieee.org/document/9672305 – 2021

Electroencephalogram (EEG) is prone to several artifacts that often lead to the misclassification of neural features in Brain-Computer Interfaces (BCI). Traditionally, detecting and removing bad EEG electrodes (or channels) is often the first and most critical step in cleaning the data. There are a few automated tools, and each uses its statistical signal processing techniques with tunable hyperparameters (e.g., the z-score threshold for amplitude-based outlier detection). To our knowledge, an objective deep-learning approach for this problem is still missing. This paper proposes *cleanEEGNet*, a Convolutional Neural Network, to identify the bad channels in EEG signals. We carefully chose the model hyperparameters (i.e., kernel size and stride) to mimic the conventional detection of bad channels performed via visual inspection. An open-source dataset from OpenNeuro with annotated bad channels is used to train and validate the network. For a benchmark comparison, we chose four state-of-the-art automated conventional methods for bad channel removal, including FASTER and HAPPE. Among them, HAPPE performed the best, achieving a balanced accuracy of 66%, while *cleanEEGNet* outperformed HAPPE by 17% with a balanced accuracy of 78%.

Interpretable CNN for Single-Channel Artifacts Detection in Raw EEG Signals

https://ieeexplore.ieee.org/document/9881381 – 2022

Electroencephalogram (EEG) signals recorded from the scalp are often affected by artifacts. Most existing artifact detection methods rely on multi-channel statistics such as inter-channel correlation. Recently, there has been a growing interest in realizing single-channel EEG systems to promote everyday use, demanding novel artifacts detection techniques. This paper presents validation results for single-channel artifacts detection in raw EEG signals using four neural architectures: a one-dimensional CNN (1D-CNN) - proposed by us, EEGNet, SincNet and EEGDenoiseNet. We used semi-synthetic EEG data corrupted with Ocular (EOG) and Myo-graphic (EMG) noise components to validate the approaches. Precisely, we contaminated the randomly chosen EEG channels with EOG and EMG artifacts in a controlled manner using a predefined Signal-to-Noise Ratio (SNR) such that the ground truth is known. We validated these models both in terms of classification performance and the interpretability of the learned features. Of the four models, 1D-CNN, EEGNet, and SincNet achieved a comparable classification accuracy (around 99%) and EEGDenoiseNet achieved as low as 64%. Analysing the learned filters for interpretability, we found both 1D-CNN and EEGNet clearly separates EOG (Delta and Theta) and EMG (Gamma) frequency bands from EEG. Instead, SincNet prioritized to learn EEG-specific features (Alpha and Beta) rather than artifact-related information still achieiving the comparable performance as the other two models. EEGDenoiseNet with kernel width of 3 was excluded from this evaluation as it is practically infeasible to perform FFT analysis. Finally, we also computed the number of training parameters for each model to evaluate which among them would be suitable for a resource-constrained wearable device and we found that 1D-CNN and SincNet are the most parameter-efficient, although not by a large margin.

Chapter in the book "Health Monitoring Systems"

https://www.taylorfrancis.com/chapters/edit/10.1201/9780429113390-6/biomedical-signal-analysis-1-simone-benatti-victor-kartsch-fabio-montagna-elisabetta-farella-velu-kumaravel – 2019
My master thesis is included in the chapter "Biomedical Signal Analysis 1" of this book.

REVIEWER FOR INTERNATIONAL JOURNALS/CONFERENCES

I have been a direct or delegated reviewer for the following Journals and Conferences

- Journal of Neural Engineering
- Journal of Psychophysiology

- IEEE EMBC Conference
- DATE Conference
- IEEE SAS Symposium

LANGUAGE SKILLS

Mother tongue(s): **TAMIL**

Other language(s):

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken production	Spoken interaction	
ENGLISH	C1	C1	C1	C1	C1
ITALIAN	B1	A2	B1	B1	A2
FRENCH	A1	A1	A1	A1	A1

Levels: A1 and A2: Basic user; B1 and B2: Independent user; C1 and C2: Proficient user